[PROC. ROY. SOC. VICTORIA, 30 (N.S.), PT. II., 1918].

# ART. VIII.—*The Physiography of the Glenelg River*

BY CHARLES FENNER, D.Sc.

(With Plate XIX.)

[Read 13th September, 1917].





## I.—Introduction.

These notes were prepared in connection with the University Survey Camp, conducted in this area under Professor Skeats during the vacation of January, 1914. They are published with the permission of the Geological Survey of Victoria, under whose auspices this survey camp was arranged.

The Glenelg River is one of the largest and most important of Victorian streams. It is situated in the south-western corner of Victoria, and drains an area of about 4200 square miles. Major Mitchell, who discovered and named the river on July 31st, 1836, records that the native name was Temiángandgeen, "a name unfortunately too long to be introduced into maps."[1]

1 Major Mitchell's Journal, vol. ii., p. 212.

Both the Glenelg and its chief tributary, the Wannon, rise in the bold meridional sandstone ranges of the Grampians, and drain nearly all the Victorian territory west and south thence to the sea, emptying into Discovery Bay. When nearing the coast the river makes a long westerly sweep, looping across the border into South Australia, thence it doubles back round a coastal border hill, Mt. Ruskin, and enters the sea on the Victorian coast.

A casual examination of the river basin (see Plate XIX.) shows it to be curiously one-sided, and detailed enquiry into its physiographic history brings out many interesting details of the changes which have occurred during its lifetime.

It is very interesting to note the first impressions gained by that talented explorer and keen observer, Major Mitchell, in his traverse of this area. In the latter part of July, 1836, his expedition had reached the very flat land (average elevation, 530 ft.), which lies immediately north of the Glenelg basin. Here, since it was winter and very wet, he had great difficulties in getting his bullocks, waggons, etc., over the soft, swampy, sodden ground. After floundering on through lakes and swamps for many days, ever seeking solid ground, he made this entry on July 30 : "By pursuing a course towards the base of the friendly mountains,[1] I hoped that we should at length intercept some stream, channel, or valley, where we might find a drier soil, and so escape from the region of lakes. . . . From here the pinnacled summits of the Victoria range presented an outline of the grandest character. The noble coronet of rocks was indeed a cheering object to us after having been so long half-immersed in mud. . . . I found at length, to my great delight, . . . a valley, where we finally encamped on a fine stream[2] flowing to the south-west over granite rocks (white felspar, quartz and silvery mica). . . . We had solid granite beneath us; and, instead of a level horizon, the finely rounded points of ground presented by the sides of a valley thinly wooded and thickly covered with grass. This transition, from all we sought to avoid to all we could desire in the character of the country, was so agreeable, that I can record that evening as one of the happiest of my life."

It was on the next day, July 31, that Mitchell actually discovered the Glenelg. (See Fig. 1.) Although he shows in all his records a keen instinctive knowledge for physiographic features, the peculiar nature of the course of this river for many days presented a com-

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1 The Grampians.

2 Probably Reilly's Creek.

plete puzzle to him. Of his first contact with the river he writes: "We now moved merrily over hill and dale, but were soon, however, brought to a full stop by a fine river flowing, at the point where we met it, nearly south-west. The banks were thickly overhung with bushes of the mimosa, festooned in a very picturesque manner with the wild vine. The river was everywhere deep and full, . . . on an average 120 feet wide and 12 feet deep. Granite protruded in some places, but in general the bold features of the valley through which this stream flowed were beautifully smooth and swelling. . . . A little rill then murmured through each ravine,

"'Whose scattered streams from granite basins burst,
Leap into life, and sparkling woo your thirst.'

It seemed that the land was everywhere alike good, alike beautiful."

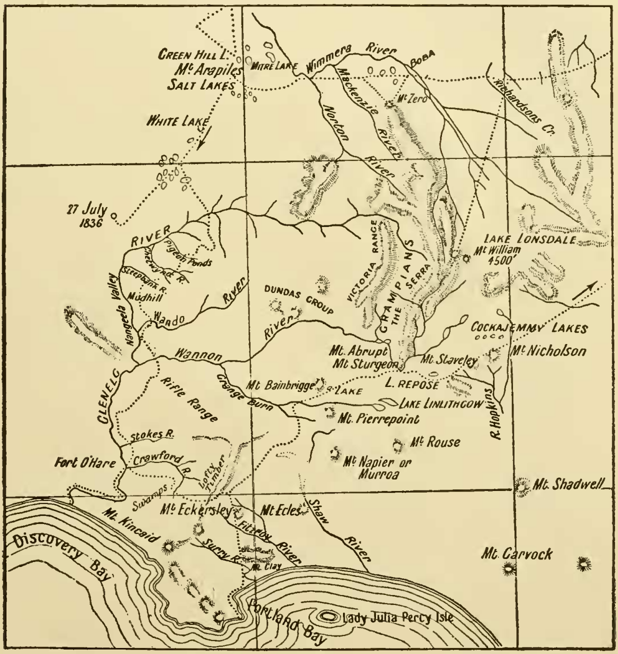



**Fig. 1.**—Map of the Glenelg Basin, as prepared by Major Mitchell in 1836. The spelling, heights, &c., are as given by Mitchell. His route, with dates, is shown.

## II.—General Description of the Area.

The accompanying plan (Plate XIX.) shows the courses of the main stream, and its most important tributaries; the extent of the basin is shown by a dotted line, and the approximate contours of the area are also shown. Fig. 1 is copied from Mitchell's first map of the river and its tributaries, and shows the route of his expedition.

As has been previously noted, there is a distinct preponderance of tributaries to the east, and especially to the north-east. Indeed, except for a few short valleys, there are no tributaries on the western side at all. In order to more systematically consider the various features, we may conveniently divide the area into four parts; these are numbered respectively, A, B, C, and D in Plate XIX.

The chief distinctions between these four divisions consist in the nature of the drainage, but there are other characteristics which may be briefly summarised as follows :—

A.—The tract between the Glenelg and the South Australian border; low land, sloping gently to west and south-west. Irregularly timbered, mostly scrubby; poorly drained, abounding in swamps and lakes with low separating ridges, often of limestone; some dairying and grazing, sparsely populated. Recent work shows good agricultural possibilities in this area where extensive drainage schemes are undertaken.

B.—The tract north of the Glenelg, towards Goroke and Natimuk; slightly better populated, and with a better class of land, grazing, some wine and wheat; timber mostly scrubby, but abundant good redgum; badly drained, abounding in lakes and swamps, and with a few wandering "creeks."

C.—The tract enclosed by the Upper Glenelg and the Wannon; of varied elevation, rising in the Dundas highlands to 1535 feet; well drained by streams flowing north, north-west, and south; well peopled for the most part; good land, in places excellent, especially in the open downs to the south. The underlying rocks of this important area consist of a series of ancient gneisses, schists, slates, cherts, with acid and basic igneous intrusives. The most elevated portions (Grampians, Dundas, etc.) consist of lower carboniferous sediments—purple and grey sandstones and quartzites, strongly faulted; in the lower part of area C, calcareous jurassic mudstones occur; practically the whole area, up to 1000 feet, has been covered by marine deposits of late tertiary (? pliocene) age.

D.—The south-eastern part of the basin, extending towards Portland; lower land than C, but somewhat diversified; in the north excellent land as at Merino, etc., when the level-bedded jurassic mudstones occur; further south heavily timbered, but with big areas of "heath country." Open basalt plains cover about one-third of the area, the remainder consisting of level-bedded ferruginous and calcareous marine tertiaries (? pliocene, etc.); a few streams draining west and north-west.

## III.—Rainfall.

The rainfall of the whole area is good, being a little above the average for the State. As will be seen, the distinctive nature of the topography and drainage in the four areas A, B, C, D, does not appear to be at all due to the rainfall, but rather a product of three factors: (a) elevation, (b) slope, (c) nature of the rocks. Mr. H. A. Hunt, the Commonwealth meteorologist, has courteously supplied the following details of the rainfall, based on 10 years' records. It will be noted that the only appreciable distinction is that the flat plains of area B, stretching from Apsley to Toolondo, suffer to the extent of five inches per annum, the rain-bearing winds having parted with a good deal of their moisture before this area is reached.

*Annual Averages for Ten Years.*

| Area A. | | Area B. | |
|---|---|---|---|
| Dartmoor | 32.89 ins. | Apsley | 25.10 ins. |
| Dergholm | 26.86 | Edenhope | 25.82 |
| Nangeela | 26.92 | Pine Hills | 22.43 |
| Poolaijelo | 28.26 | Charam | 22.16 |
| Strathdownie | 27.48 | Douglas | 19.42 |
| | | Telangatuk | 24.04 |
| Av. | 28.48 | Av. | 23.16 |

| Area C. | | Area D. | |
|---|---|---|---|
| Balmoral | 24.81 ins. | Portland | 33.54 ins. |
| Carapook | 25.54 | Branxholme | 24.04 |
| Roseneath | 27.55 | Condah | 28.18 |
| Coleraine | 24.46 | Croxton E. | 27.57 |
| Tulse Hill | 29.77 | Dunkeld | 29.69 |
| Melville Park | 29.51 | Hamilton | 28.00 |
| Montajup | 26.36 | Merino | 29.83 |
| Mooralla | 29.26 | | |
| Av | 27.16 | Av. | 28.69 |

## IV.—Mountains and Hills.

As stated in the last section, differences of general elevation appear to have played a large part in producing the diverse features of the four divisions. Generally speaking, we may sum these differences up as follows (see Plate XIX.):—

A.—Low, flat, gently sloping south-west; average elevation 2-300 feet, rises to 400.

B.—Higher land, fairly level, difficult to detect any general direction of slope, but probably slopes to north and west; average elevation 4-500 feet.

C.—Comparatively high lands, average 7-900 feet, rises in the western part to 1500 feet, and in the east to 3000 feet and over; deeply dissected by streams flowing in all directions from a central east-west ridge.

D.—Somewhat similar in elevation to area B, but with much more diversity of hill and valley; variety also introduced by volcanic hills and flows.

Apart from these considerations of elevation, the chief cause of the present disposition of the Glenelg and its tributaries lies in the manner of their growth. The basin of this stream, although itself of comparatively recent origin, appears to have still more recently, added greatly to its territory in two ways:—

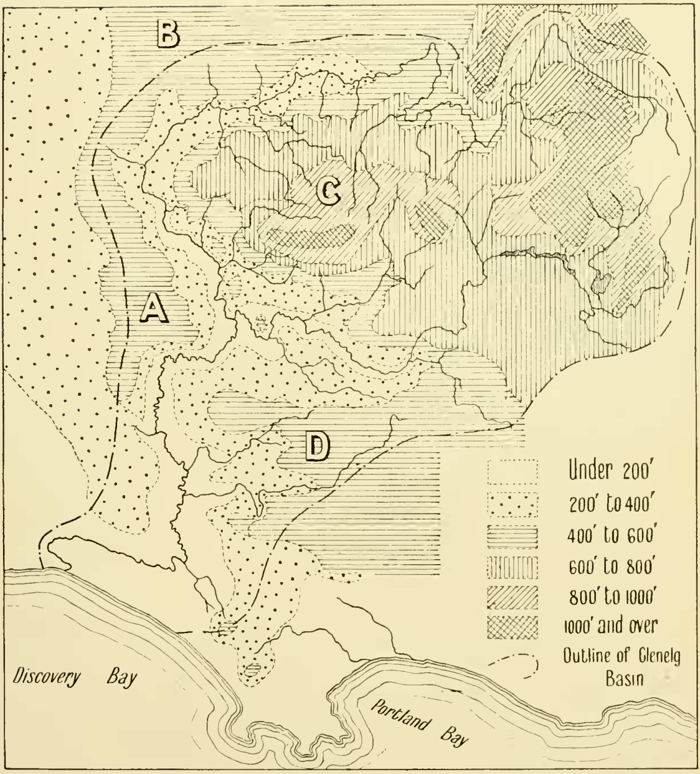
(i.) Aggressively, by the capture of less fortunately situated streams.

(ii.) Passively, by the diversion of neighbouring streams into the Glenelg basin on account of lava flows.

These possibilities will be dealt with more fully in a later section. Meanwhile, having accomplished a general survey of the whole area, we may deal with hill and valley in somewhat more detail.

(a) Grampians and Dundas Highands.—In these mountains most of the streams in the basin have their origins. They form the outstanding mountain feature of western Victoria, and consist of upper palaeozoic indurated sandstones and quartzites, block-faulted, with faults roughly north and south, the scarps facing east and the dip slope to the west. The Grampians were discovered and named by Mitchell, who in 1836 ascended the highest peak, Mount William (3827 ft.), and spent a freezing night on its summit. Mount Dundas (1535 ft.) is the extreme western member of the group.

(b) Continuation of the "Main Divide."—One point is worthy of discussion here since it bears on the question of the Main Divide




Map of the Glenelg River basin, showing the approximate relief of the area. In the high area below the letter C (over 1,000 feet), Mount Dundas rises to a height of 1,535 feet. In the Grampians area, in the north-east, where the shading also shows "over 1,000 feet," the ranges average about 2,000 feet (Mount William, 3,827 feet).

of Victoria. Evidence is gradually being accumulated which appears to show that this, our chief watershed, although of very great diversity in material, has yet a unity of structure. This general structure is of the "block-fault type," and in this the Grampians, Serra, Victoria, Black, and Dundas ranges are distinct partakers (if not the suggesters of the idea).[1]

A writer on the Geography of Australia[2] says: "The Pyrenees may be considered as the end of the Great Dividing Range on the continent." This, of course, suggests that the Pyrenees are also the end of the Main Divide of Victoria. Further, the much-debated uniform hachure line which marks the Divide on most maps of our State usually ends about Ararat.

As a matter of fact, this Divide, regarded as a structural feature of Victoria, does not end until the Glenelg is reached, less than 40 miles from the western border (see accompanying plate). The unity of structure hitherto referred to must cause the inclusion of the Grampians in the Divide, as also does the fact of the division of the north and south flowing drainage (see Fig. 2). The low gap at Ararat, where the head waters of the Mount William creek (northern) and the River Hopkins (southern) are almost without any separating elevation does not militate against this, nor does the similar gap west of the Victoria Range. Mr. T .S. Hart, who has given many years of careful study to the western highlands of Victoria, has shown them to consist throughout of a series of north-south ranges, with intervening north-south valleys.[3]

The railway departments of Victoria and South Australia have kindly provided sufficient reliable data of heights to allow of the construction of sections from north to south throughout the area here dealt with, and these clearly indicate the continuation of the Main Divide right to the Glenelg. There it gently plunges below the tertiary plains of the Murray estuary.

(c) Minor Elevations.—Hills which would come under this head are abundant and of great variety:—

(i.) Low-rounded hills, wholly of coast plain material, such as Mount Clay and Mount Kincaid, are residuals. The timbered ranges throughout area D are mostly of this type.

(ii.) Numerous hills in the Casterton-Wando Vale area are of soft jurassic mudstones capped by a level layer of ferruginous tertiary

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1 See T. S. Hart. "Highlands and Main Divide of Western Victoria," Proc. Roy. Soc. Victoria, December 1907, p. 270, line 36.

2 Commonwealth Year Book, No. 3. 1910.

3 B.A.A.S., Melb., 1914. "The Central Highlands and Main Divide of Victoria." T. S. Hart.

material. Robin Hill, near Corea Creek, with its flat top, may be cited as characteristic of this class.

(iii.) Around Casterton, Coleraine, and Merino, we find beautifully undulating, well-grassed country, the low rounded hills bearing witness to the evenness and softness of the level-bedded jurassic mudstones in which the streams have done their work. In places where the slopes are steeper, landslips are characteristic features; their abundance is probably due to the "greasy" nature of these felspathic mudstones, combined with their porosity. On a small scale interesting complications in the drainage of these hills have been caused by the landslips. The general fertile appearance of this part of the country greatly impressed Mitchell, and on his suggestion the Hentys in 1837, brought stock up from Portland, settling in the neighbourhood of the present township of Henty. In his pamphlet on "The First Settlers in Victoria," Henry Henty says of this venture: "When they caught sight of the country, 'Why, here is Sussex!' they exclaimed, 'Sussex without a building, Sussex without inhabitants, Sussex all our own.' They galloped their horses for joy, cheering and throwing up their hats."

(iv.) In area A, long low ridges, generally trending north-west, run away into South Australia. In these limestone often plays a large part, and caves are frequent.

(v.) Granite hills occur rarely, Bracken Hill is an example. Most of these hills are residuals, the ancient, resistant bed-rock (granites, gneisses, slates, etc.), having been deeply dissected in places by the Glenelg and its tributaries; other hills of this class are very ancient physiographic features, relics of a prior peneplanation, covered by lake and marine deposits, and more recently uncovered by stream action. The Hummocks, near Bracken Hill, will be dealt with more fully at a later stage. Volcanic hills, e.g.. Mount Bainbrigge and Mount Eckersley, occur, mostly in the south-east.

## V.—Valleys and Streams.

(a) Glenelg River.—The valley of the Glenelg lies almost wholly in those rocks of coastal plain origin, which are uniformly coloured sage-green on our geological maps. Accepting all these beds as of one age, and as Pliocene, we see that the development of the river must be still more recent, and we thus have a freedom from any effects of complicatory prior drainage-systems, such as must be considered in dealing with most other Victorian rivers.

Mr. T. S. Hart[1] believes the Main Divide of Victoria to have been slowly uplifted along an east-west line, with trough faults on either side. This elevation amounts to some 6000 feet in the extreme east, and becomes gradually less westward, so that it seems most likely that in the area under consideration we have the last traces of this great hoist as it gradually decreased to nothingness. To the south, at Portland, a proved depth of 2265 feet[2] of tertiary sediments indicates a very great subsidence there.

If we picture the whole of the old Murray estuary as slowly rising above sea-level, it is evident that the first part uncovered by the sea would be the Dundas Highlands—our area C. We should then have developed there the two sets of short consequent streams that still exist (see map). One set, Chetwynd, Pigeon Ponds, Mathers' creeks, etc., flowing north, and the other set, Dundas, Steep Bank, Wando, Koonong Wootong, etc., more or less southerly. A certain amount of capture in the region of their headwaters has slightly but not materially affected these streams since then. (See Fig. 2.)

The remaining flatter part of the estuary floor would probably rise a little more slowly, the sea apparently receding along a north-west south-east coastline. Such a movement appears to be still continuing, probably with minor oscillations, and is aided in its reclamation work by the ridges and sand-dunes built by winds and currents. The north-north-west trend of the parallel ridges and swamps in that corner of South Australia is strongly suggestive of this, and the part played by coastal dunes during the uprising is evidenced by the occurrence, all through the areas concerned, of patches of dune sand, sometimes very extensive, at other times blown away and re-collected in recent hollows. With the continued recession of the sea, the northern streams would endeavour to make their way north, probably a little west; while the southern streams would gather to form two or three more or less uniformly south flowing streams (see Fig. 2). Of these, the Glenelg would be one, and a stream formed by the union of the Dwyer's Main Creek, and the Upper Wannon would almost certainly be another.

The sad lack of grade to the north would act against any definite valleys being cut out and adhered to there, and we should probably have our northern streams degenerating into chains of shallow lakes, such as still occur in area B. The sister stream, the Wim-

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1 Proc. Roy. Soc. Victoria, December, 1907, and B.A.A.S., 1914.

2 Quoted by H. Herman, Vict. Handbook, B.A.A.S., 1914, from Vict. boring records.

mera, having a bigger body of water, has made an heroic but unsuccessful effort to persist in flowing on to reach the Murray in the north.

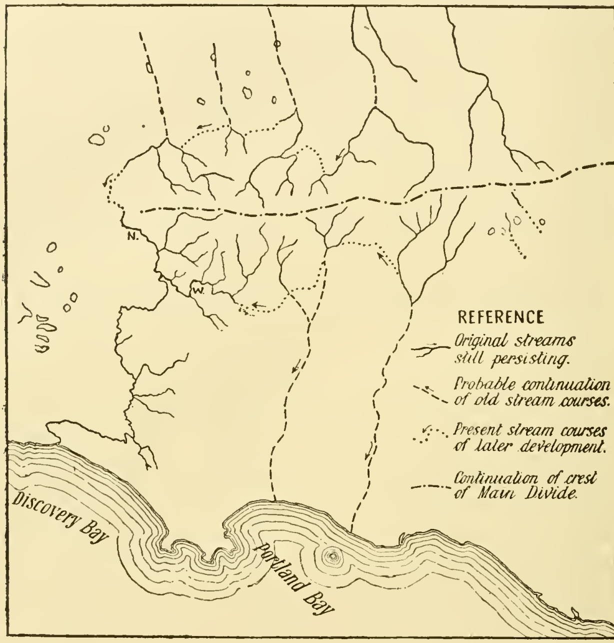


**Fig.** 2.—Diagram to indicate the mode of origin of the present drainage system of the Glenelg, as it is conceived to have taken place. The old stream courses to the north, shown by broken lines, probably never firmly established themselves, owing to the lack of grade; while those shown to the southward have been covered by the "newer basalt" flows.

The southern streams were more blessed, and of these fortune seems to have favoured the Glenelg. With a good slope, soft rocks, and a good supply of water, this stream would rapidly deepen its valley, receiving few tributaries en route. Nearly all that were developed naturally came from the east, because the gentle tilt of the land surface to the south-west would tend to direct the western water away from the river, to collect in swamps and lakes, as is still the case.

As the land rose the Glenelg would continue to deepen its valley and increase its territory. In the soft jurassic rocks the valley is wide, and flood-plains, cut-offs, and terraces are to be seen; but in the somewhat harder, level-bedded limestones lower down the course, below Dartmoor, the river has cut down into a steep valley with high precipitous cliffs that still persist.

At this time we may picture two chief tributaries of the Glenelg —an eastern one, the Wannon (W. Fig. 2), and a more northern, to which we may give Mitchell's name—the Nangeela valley (N. Fig. 2). The Nangeela would have everything in its favour to proceed with vigorous headward erosion, and we may picture it advancing more and more to the north, rounding the Dundas highlands, and ultimately, one by one, capturing the struggling northward streams, eventually reaching back into the territory of the Wimmera itself, as indicated in Fig. 2.

In August, 1836, Mitchell[1] made the following observations regarding the flow of the river at a point about four miles north of the junction with the Stokes River:—Average breadth, 35 yds.; mean depth, 17 ft.; velocity of current, 1863 yds per hour. This represents a flow of about 62,000,000 gallons per hour. The river is subject to very severe floods, when, of course, the flow is even greater. On the other hand, in summer time, the surface flow often practically ceases. This was the case at the time of our camp there in January, 1914.

The absence of any deep, wide estuary at the mouth of the Glenelg was a great disappointment to Mitchell. The mouth is shallow, and shoaled with shifting sand bars. On August 20, 1836, Mitchell wrote in his journal: "The day was squally, with rain, nevertheless, during an interval of sunshine I obtained the sun's meridian altitude, making the latitude 38° 2′ 58″ S. I also completed, by 2 p.m., my survey of the mouth of the river and the surrounding country. . . . On re-entering the river from the sea, I presented the men with a bottle of whisky, with which it was formally named the Glenelg, after the present Secretary of State for the Colonies."

(b) The Wannon.—This tributary, whose native name has fortunately been preserved by Mitchell, was favourably placed in the soft jurassic and tertiary rocks. There are, however, two or three features in the present Wannon valley that demand explanation. The valley may be divided into three very distinct tracts. In the lower Wannon, from Tahara to Casterton, we have a fine stream,

1 Journal, vol. ii., p. 218.

winding in a definite channel through a wide, middle-aged valley (see Plate XIX.). In the central tract of the Wannon, up as far as Mount Sturgeon, we have the river taking a most unexpected loop to the north, towards the mountains, and thence wandering sluggishly and wide, with practically no defined valley, north-west, then west, and south-west, passing over waterfalls into the lower Wannon in the neighbourhood of Tahara. Still further towards the source we have Dwyer's Main Creek and the Upper Wannon (above Mt. Sturgeon) flowing almost due south in deep stable valleys in the hard rocks of the Grampians.

We thus have an upper and a lower tract of more mature age, with a central part of extreme youth. As before indicated, there appears to be no doubt that this uppermost part, with Dwyer's Main Creek, originally flowed on to the south as a separate river; also that the lower Wannon did not extend nearly so far eastward as at present (see Fig. 3). With the advent of the newer basalt period, however, a great sheet of lava effectually dammed up these present tributaries of the Upper Wannon, in the neighbourhood of Mt. Sturgeon, and forced the streams to slowly find their swampy way right round the northern margin of the basalt sheet, finally reaching the wider and more mature valley of the lower Wannon. Thus, to use the terminology of rivers, the Lower Wannon is a "consequent" stream, the extreme Upper Wannon is a "captured consequent," while the central part may be called an "insequent" stream (a term used by Andrews, "Physical Geography of N.S.W.," p. 36).

The deeper valley of the Lower Wannon is now endeavouring by means of headward erosion, as at the Wannon and Nigretta falls, to reduce the three parts of the stream to a more harmonious grade. The events are so recent, and the evidence so clear, that any geological map of Victoria will evidence the truth of this theory; especially is this so if taken in conjunction with the more detailed county maps as to the nature and direction of the river's course.

It should be noted also that of the two older tracts of the Wannon, the lower one—from Tahara to Casterton—is wholly due to erosion. The upper part, within the Grampians, lies in valleys that are probably of tectonic origin, and older than the Tahara-Casterton portion.

(c) Wando and Wando Vale Ponds.—These two streams rise in the western part of the Dundas highlands, and flow south-westerly, converging towards the Hummocks. Passing through the latter hill in two narrow gorges, they junction, and flow into the Glenelg near the "Retreat" homestead. Since the work done by the survey party was largely in their basins, they were more closely

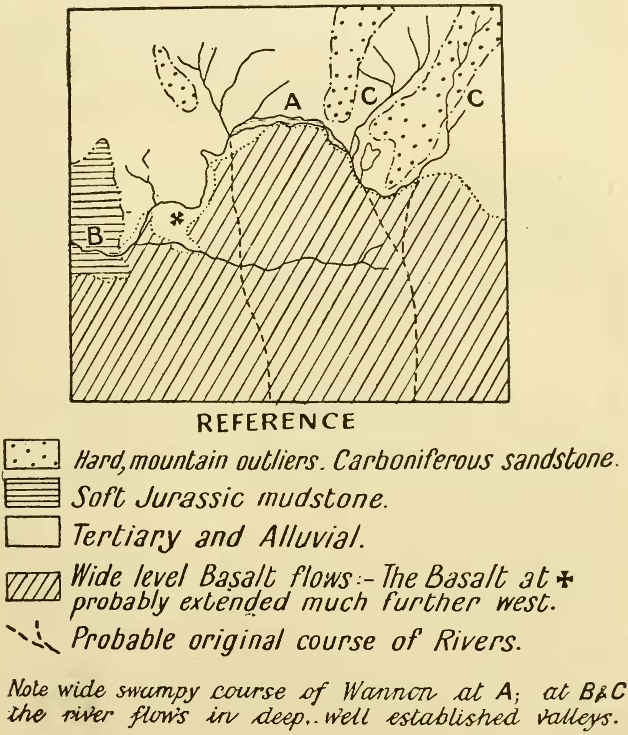


**Fig. 3.**—Geological plan to illustrate more clearly the effect of the lava sheet in determining the present course of the Wannon. The carboniferous sandstones are here referred to as "outliers," in respect to the very ancient underlying bed-rock, which is covered by a thin layer of marine tertiary and recent alluvial material.

observed than other similar tributaries of the Glenelg. The name Wándo was given by Mitchell, who appears to have elicited it from an aboriginal female whom he interrogated there. The course of these streams was decided by and set out on the sloping coastal plain. When their valleys were once selected, they would soon carve through the lose, level-bedded tertiary sediments, and then cut down into the soft, decomposed jurassic mudstones. Under such conditions very wide, open U-shaped valleys are found.

Underlying these last-mentioned sediments, and in some cases immediately below the tertiaries, very hard gneisses and granites were met, with the result that narrow, fairly steep-sided gorges

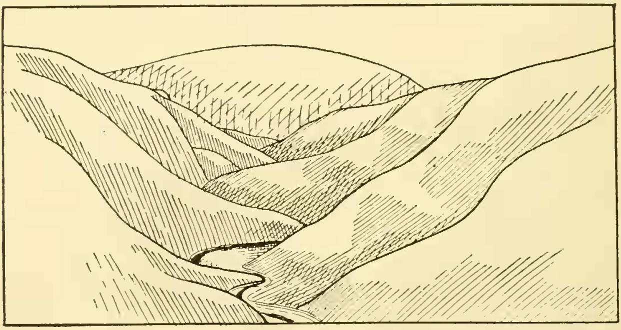

**Fig. 4.**—Sketch of gorge cut by Robertson's Creek into the hard schists and gneisses which underlie the thin capping of level-bedded marine tertiaries.

mark the places where such superimposition occurred. Good examples of such gorges are those of the Wando and Robertson's Creek (Fig. 4), that of Corea Creek is much more precipitous; they provide patches of rugged and interesting scenery, quite a break in the monotony of the level uplands into which they are cut.

In the lower Wando and Wando Vale Ponds the course of the stream, with its numerous large waterholes, has within recent years quite silted up; probably this is mainly due to the opening up of the hillside lands by agriculture. In summer the streams cease to flow, but good water for stock may always be procured by scooping out a hole in the sands of the creek bed.

(d) The Upper Glenelg and "Brim Spring Gap."—The uppermost parts of the Glenelg show a tortuous course. The stream rises in the heart of the Grampians, at the "Chimney Gap," just over the ridge from one of the south-flowing tributaries of the Wannon. It then flows north-east 12 miles, north-west 18 miles, and then south-southeast about 18 miles, forming a V-shaped loop with the sharp angle to the north. This angle is at a point east of the Black Range, near Brim Spring. A low gap occurs, and it is interesting to know that some years ago a scheme was proposed whereby a canal was to be dug to carry the water from the upper Glenelg across to the Wimmera on the north. While not able to visit the spot, the writer has obtained much valuable information from the details of the railway survey through the gap, and also from Miss Sinclair, of the Brim Spring school. There appears to be evidence that the upper Glenelg originally flowed north, perhaps down Norton's Creek, to the Wimmera. This area is well worth closer investigation.

(e) Minor Streams.—A number of other streams present peculiarities in their courses, and leave much room for detailed physiographic work. Of these may be mentioned the Pigeon Ponds, Steep Bank rivulet, Harvester Creek, and the Stokes River; the latter shows a remarkably sharp southern loop north of the township of Lyons, probably due to the lava stream having filled up part of its former valley.

## VI.—Lakes.

The basin of the Glenelg has an extremely ill-defined boundary. Except in the case of the Grampian district, low, flat, swampy divides are the rule. On the eastern side this low divide has been carefully selected as the route for the Dunkeld-Portland portion of the railway; lakes and swamps, lying on the basalt sheet, are common here. To the north, in area B, the very numerous lakes are perhaps to some extent relics of the streams which attempted to make their way northwards before being captured by the active headward erosion of the Glenelg; there are no streams whatever adjacent to the Glenelg valley here. In the north-west one or two ill-defined creeks occur, such as the Mosquito creek, towards Apsley. To the west of the Glenelg, if we except a few minor streamlets, there are no tributaries whatever; the water collects in the depressions, and is got rid of by evaporation and percolation. Most of these swamps, especially across the border, are elongated along north-north-west axes. Woods[1] records that at flood times the Dismal Swamp—a large swamp north of Mount Gambier—drains eastward into the Glenelg.

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1 Geological Observations in South Australia. J. E. Woods, 1862.

The lakes may be roughly classified as (i.) solution lakes, (ii.) cut-offs, (iii.) basalt dammed, and (iv.) those on basalt sheet.

(i) Solution Lakes.—This type, dealt with by Professor Gregory,[2] is common. Mitchell had close experience with a large number, and deals with them in some detail. Undoubtedly wind erosion plays a large part in forming many of these lakes, as shown by the frequently occurring crescentic bank of sand on the eastern shores. A beautiful drawing of the group called the Greenhill lakes is given by Mitchell in Vol. II. of his journal, plate XXXII.

(ii) Cut-offs. As before mentioned, these occur in the wider and more mature portions of the Wannon and Glenelg, especially where jurassic mudstones are dominant.

(iii.) Swamps and lakes caused by the damming up of streams by lava flows are common northward from Glenthompson towards Mount William. These include the Cockajemmy lakes. Larger ones occur west of Mount Abrupt.

(iv.) The lakes found on the basalt sheet itself are numerous and shallow. They are similar to those found all over south-western Victoria, and bear witness to the immaturity of the drainage systems. They are usually ascribed to one or more of the following agencies:—Sagging of the basalt, the meeting of two or more lava flows, wind erosion, and more rarely, crater depressions.

## VII.—The Hummocks.

This remarkable natural feature deserves a special section for itself. It consists of a hill, a little over 450 feet high, cut through by two steep-sided gorges—those of the Wando and the Wando Vale ponds. An observer coming eastwards up the wide, open valley of the Wando, cannot fail to be struck by the fact that this hill lies right across the valley almost at right angles to the course of the stream. Closer observation is necessary to show that it is cut through by the two streams named, which narrow their valleys down to gorges a chain or less in width. A detailed survey of the immediate area was made under the direction of Mr. O. A. L. Whitelaw, Field Geologist, Geological Survey of Victoria, and is shown in Figure 5.

To the traveller along the Harrow road to the east, a similar puzzle is presented of two wide U-shaped valleys suddenly narrowed to two small V-shaped guts. Since it lies on Major Mitchell's

2 Geography of Victoria, pp. 132 *et seq.*

route, we may be sure so keen an observer would not pass it without remark. He records that the native name of the hill now known as the "Hummocks," was Kingànyu, and adds: "Proceeding along the valley, the stream on our left (the Wando) vanished at an isolated rocky hill; but, on closer examination, I found the

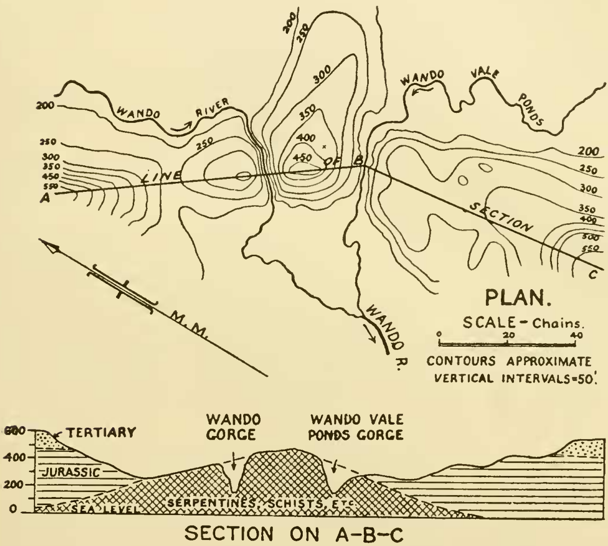


**Fig. 5.**—Plan and section of "The Hummocks." The contours are from data collected by Mr. P. B. Nye. The plan shows clearly the wide valleys carved out by the two streams in the softer rocks both above and below the "gorges."

apparent barrier cleft in two, and that the water passed through, roaring over rocks. This was rather a singular feature in an open valley, where the ground on each side was almost as low as the rocky bed of the stream itself. The hill was composed of granular felspar, in a state of decomposition.[1] It is not so easy to suppose that the river could ever have watered the valley in its present state, and forced its way since through that isolated hill of hard rock, as to suppose that the rock now isolated originally contained

1 It is largely serpentine, with talc schists, quartz schists, phyllites, etc.

a chasm, and afforded once the lowest channel for the water, before the valley now so open had been scooped out on either side by gradual decomposition." When reading this interesting explanation we must remember that it was written in 1836.

The Hummocks have received a fair amount of attention from geologists. They were visited about 1886 by F. L. Krause, who figured them in the Mines Department report of that year. Strangely enough, he did not visit the second gorge, that of the Wando Vale Ponds, and refers to it as a "road cutting." It is evident that the Wando and the Wando Vale are at this point "superimposed streams," with wonderfully clear and convincing characteristics.

When the streams commenced their downward cutting, they were in soft tertiary material; the ridge of resistant rock lay hidden less than 200 feet felow, and almost at right angles to their course. With the gradual deepening of their valleys, this hard ridge was encountered, and there was nothing left to do but to "go on with the work"; the two V-shaped gorges are the result. The great contrast between the very hard rock of the Hummocks, and the very easily eroded jurassic and tertiary material under which it was hidden, have given this feature much greater distinction and interest (see Fig. 5).

## General Conclusions.

Of much interest in this area are the traces found of ancient physiographic features, preserved by burial under sediments of various ages and subsequently exposed by stream action. Of those that were investigated in the field by the survey party, the oldest may be referred to as the pre-jurassic.

This ancient landscape has left many traces of its outlines, such as may be seen in the Wando Vale district. It was evidently a surface of low relief, with its ridges and valleys carved out in a series of ancient resistant rocks. The most northern part of the jurassic lake system, as far as it has been preserved, embraced this area, and the accumulating sediments of this lake gradually covered the submerged landscape.

Thus it was in part preserved until comparatively recent times. Of these ridges, now partly exposed, but still with jurassics overlapping their flanks, we may mention Cashmere Hill, Bracken Hill, and the ancient tablelands exposed in the Robertson's Creek and Wando gorges. Clearest of all, however, in the Hummocks (Fig. 5),

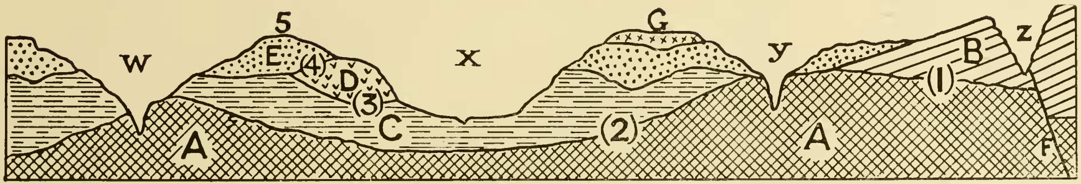


**Fig. 6.**—Diagrammatic section (composite) to show (a) the relationships of the various rock types to one another, (b) the various "erosion periods" of which records are found in the area and (c) the general characteristics of the present valleys and hills in the Glenelg River basin. A detailed account of this section (with references to the letters and figures) will be found in the context.

so venerable a feature that it can only be regarded with awe. Except for the two gorges, it stands to-day in all likelihood with the same general outline that it presented to the sun and wind when it formed part of the landscape of those extremely remote mesozoic ages.

Figure 6 represents in a diagrammatic way the chief features of importance that have been referred to in this paper. The various letters and figures of that diagram are explained below, and will serve as a general recapitulation.

### (*a*) *Rock Types.*

A.—The bedrock of the area, outcropping abundantly in the northern parts, and greatly influencing the physiographic features (see A. Fig. 6). As far as known it is non-fossiliferous; it consists of mica schists, talc schists, phyllites, slates, etc., intruded by both acid and basic plutonics and dykes. Many ages of rocks are perhaps represented in this complex, but the youngest present may be taken as not younger than ordovician. These rocks are on the whole very resistant to weathering and erosion.

B.—The faulted and tilted sediments of the Grampians and Mt. Dundas (probably Lower Carboniferous); grey and purple mudstones, sandstones, and quartzites. These are strongly resistant to erosion, and form the highest land in Western Victoria, comprising much magnificent mountain scenery. The letter F in Fig. 6 indicates the faulting which is so prominent in these rocks.

C.—Jurassic lacustrine sediments, consisting of felspathic mudstones, sandstones, and occasional grits; frequently calcareous, and in places carbonaceous; nearly always level-bedded; weather easily and good outcrops are rare. Fine agricultural land, wide valleys, broad, fertile flats, and rounded hills.

D.—Older Basalts, etc.—These are taken as belonging to various periods in the tertiary. Different types occur; the relics are small and scattered. They are of minor importance from the physiographic point of view.

E.—Tertiary limestones, gravels, and sandstones often strongly ferruginous. These are in places fossiliferous; very widespread, originally covering the whole of this area up to the thousand-foot contour line. They are level-bedded, and easily eroded. In the higher areas these beds are naturally quite thin—a few feet in thickness; the deposits become thicker towards the south and west; in the southern areas they reach a depth of from two to three